DIMENSIONS NBS

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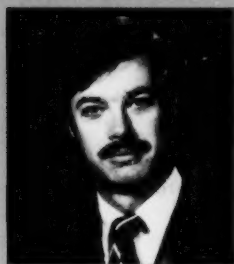
FIRE FIGHTING IN THE COMPUTER AGE See Page 2.

COMMENT

USING SCIENCE TO FIGHT FIRES



One way to achieve fame in science is to solve easy problems that look hard. The reason there aren't more famous fire researchers is that they work on hard problems that look easy. For example, the central issue in fire modeling would seem a trivial one: to predict how a fire will grow in a room, given the composition of the materials at hand and the compartment geometry. Surely, one would argue, a technology which can compute the thrust of a rocket engine can tell how quickly a bedroom will burn after a match is dropped in a wastebasket. In fact, the latter is a much tougher problem. In a rocket, we know the combustion properties of the fuel to a whisker; on the other hand, the materials found in a typical bedroom can vary widely. In a rocket, the oxygen for burning is metered from a tank or premixed with the fuel; in a room, it is part of the air which swirls in through the doors and windows. In a rocket, the smoke and hot gases leave through a nozzle; in a room, they leave by the same routes as the air comes in. In a rocket, all the burning happens in one place; in a room, the fuel, and thus the fire, may be anywhere.

Each of these complexities gives rise to an entire area of inquiry. One must develop good measurement methods for flame spread and heat release of furnishings and building materials before one can know the combustion properties of the fuel. One must understand the detailed fluid mechanics of the air and smoke flow before one can predict how much air the fire will get or where the smoke will go. One must be able to compute radiative, convective, and conductive heat transfer before one can tell how hot things will get.

Fire modeling is the final orchestration of all these considerations into a quantitative picture of a growing fire. As the article (Firefighting in the Computer Age) in this issue makes clear, it is an exciting and demanding field of research. The past decade has seen great progress, and we are now applying modeling techniques to a growing family of real fire problems . . . and we do have problems.

In fact, the United States has one of the worst fire records in the industrialized world—nearly 8,000 lives and $6 billion lost in 1979. Ironically, one reason Americans are not more fire-conscious is because big fires, which are most likely to get public attention, are rare, thanks to good building codes and effective fire departments. Most fire deaths are undramatic; they happen one or two at a time, usually in residential settings, and, as a consequence, receive little or no publicity. The killer fires involve at most a few rooms, not the whole building. Modeling tells us how these fires burn, what we can do to slow them down, and how to minimize their effects. That's certainly worth doing . . . even though it's tougher than it looks.

Frederic B. Clarke
Director, Center for Fire Research
National Bureau of Standards
A247 Polymers Building
Washington, DC 20234
301/921-3143

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FIREFIGHTING IN THE COMPUTER AGE

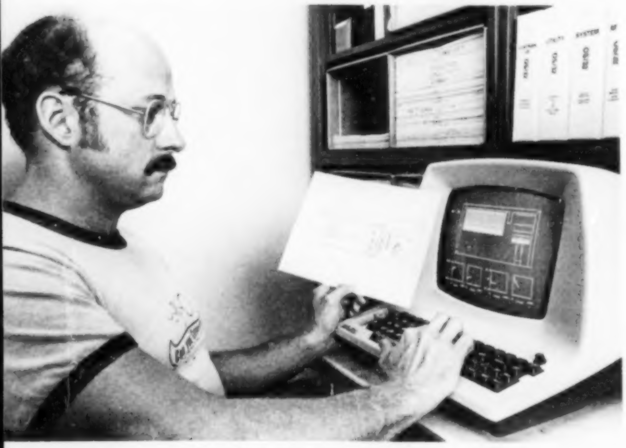
Using Math, Computer Models to Study Fire

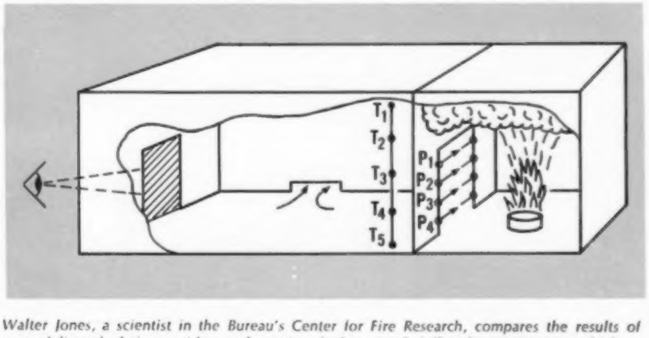
by Jeffrey P. Cohn

A blank screen lights up on Walter Jones' computer terminal at the National Bureau of Standards campus in Gaithersburg, Md. Suddenly, several squiggly lines dart across the screen. Moments later, the lines reach the top, start back down the screen's right side, and then spill over into the left side through an opening in a line that divides the screen. The squiggly lines rise to the top of the left side, too, and then descend towards the bottom, but at a slower rate.

Cohn has written articles on a range of science and technology research issues.

No, this is not the latest computer game, but rather a mathematical model that depicts how smoke spreads from a fire in one room to an adjoining room or corridor. Tests in NBS' fire laboratories could yield the same results as Jones' model. But full-scale tests cost up to $20,000 and average $10,000 to conduct. Even a simple test costs $5,000 and takes a week to set up. Further, each test reproduces only one fire situation. It is impossible to





Walter Jones, a scientist in the Bureau's Center for Fire Research, compares the results of a model's calculations with a schematic of the actual full-scale experiment which is being simulated. The enlargement of the schematic (above) shows the arrangement of photometers and thermocouples used to measure light intensity and temperature differences during an actual smoke-filling corridor experiment. Also shown is the approximate location of the cameras used during observations.

test every room size or shape, let alone all potential room contents and materials.

Thus, fire researchers at NBS and elsewhere are beginning to use mathematical models to take what is known about fires and predict what would happen if a particular fire were to break out in different-sized rooms or under different conditions. With models, researchers can assemble a fire's separate components and processes for study. Models help researchers see how these parts fit together, thereby furthering our understanding of fire as a physical and chemical phenomenon.

Modeling can also tell fire researchers what they need to know and why they need to know it. In this sense, modeling can show whether current laboratory tests develop the information which is really needed to understand fires or to set safer standards. To do that, modelers are now working towards a new generation of standards and tests.

"Our goal is to use models to predict how fires grow and the temperature and behavior of the gases and smoke they produce," says James Quintiere, head of fire modeling at the Bureau's Center for Fire Research. Jones, a senior scientist at the Center, agrees: "We hope eventually to use models to help design buildings and materials to meet higher standards of fire safety."

But that, fire modelers readily admit, is still in the future. Modeling is still too new and unverified to base new tests or designs on it alone. Most models are also too limited in scope, a problem some modelers attribute more to computers than their models. But slowly, fire researchers are developing models which can predict how small-scale fires and the smoke and gases they produce will spread. "We are now testing our models to increase their reliability and our confidence in their ability to predict," Quintiere says.

Change of Focus

The theoretical base for modern fire modeling was laid by Kunio Kawagoe in Japan in the late 1950's and by Phillip Thomas in England in the early 1960's. By the mid-1960's, NBS researchers Daniel Gross and Alexander Robertson had confirmed Kawagoe's work on room fires and John Rockett had begun to model building fires. But their work focused on fully developed fires in which a room or building was engulfed in flames. It was based on the Bureau's interest in improving the performance of building structures. These early modelers asked how long fire will burn and how hot will it get.

By the mid-1970's, however, the focus began to change. A presidential commission called attention to the large number of fire deaths in the United States compared with other countries and noted that most occurred in residences. In response, NBS modelers began to focus on the early stages of fire. The concern became one of human safety rather than the endurance of a building structure. Along with other scientists, sponsored under the National Science Foundation's RANN ("Research Applied to National Needs") program, NBS scientists now asked how fast fire plus smoke and gas will grow and spread.

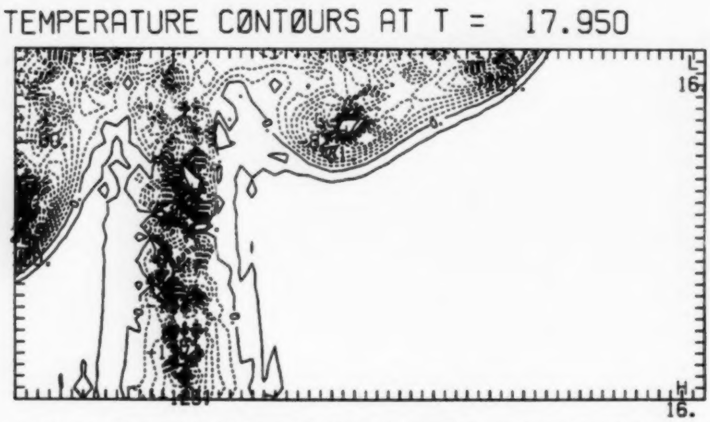
Zone and Field Models

At the Bureau as elsewhere, two kinds of models are used. Most NBS modelers use what they call a "zone model." These models divide rooms into distinct homogeneous regions governed by the fire processes. Zone models predict, for example, the average temperature of the hot upper gas zone in a room. To make predictions, zone models require data from laboratory tests on parameters like ignition source, burning rate, and rate of fire spread; smoke, energy, and gases produced; and the number and size of doors and windows. (Full-scale laboratory tests are not needed at this point, although they are used to validate the model's findings.)

Zone models give a coarse but comprehensive picture of how fire and smoke behave in a room. They predict average ceiling temperatures, for example. "You must have a good conceptual understanding of the fire phenomena to employ a zone model," Quintiere says. "Mathematics can't solve everything yet." Also, zone models start with specific information and generalize from it. But there is only so far you can go before extrapolations no longer work, says Ronald Rehm, a mathematician in the NBS Center for Applied Mathematics.

Instead, a model developed by Rehm and Howard Baum, a physicist in the NBS Center for Fire Research, attempts to calculate fire parameters at specific points in a room. Such "field models" can differentiate between the temperature of the ceiling immediately above the fire and that farther away. This second type of model gives a more detailed look at a set of parameters than do zone models. That is vital when deciding, for example, where to put smoke detectors or exit signs.

Field models may also be used to help validate zone models. For example, the field model used by Rehm and Baum can determine the shape of the smoke and hot gas region in the upper portion of a



A field model developed by NBS researchers Ronald Rehm and Howard Baum shows that for a live fire to one side of a room, the hot gases will hit the ceiling and the near wall and then plunge towards the floor while the rest of the hot gas progresses along the ceiling toward the far wall.

room during a fire. Most zone models assume a uniform layer for this region. Furthermore, Rehm and Baum have shown that if a fire is to one side of a room, the fire plume will hit the ceiling and the wall and then plunge towards the floor while the rest of the fire progresses along the ceiling.

On the other hand, NBS field models suffer from being two dimensional. They can show height and width but, unlike zone models, not breadth. Field models represent fire as a straight line (a row of wastepaper baskets stretched across a room); in that sense they can only predict theoretical, not "real" fires. Field models need not be limited to two dimensions, Rehm says; rather it is a limitation imposed by inadequate computer speed and memory. Indeed, NBS-supported researchers at the University of Notre Dame and elsewhere are now developing three-dimensional field models.

Field and zone models are not mutually exclusive, nor are they competing with each other. Indeed, the two models come at the same problem from two different approaches. Zone models can be seen as an engineering tool while field models are more of a scientific instrument.

"Our work is basic research," field modeler Baum says. "We are studying the underlying science of fire." In contrast, Leonard Cooper, an engineer who uses zone models, says, "My job is to apply modeling to actual problems. I want to help bridge the gap between fire researchers and fire practitioners by applying research to real-world fires."

Rehm and Baum use field models to predict theoretical fires. (For field models to predict actual fires, they will need to be three dimensional.) Rather than relying on preselected processes, as is done with zone models, the field model is developed using the basic principles of conservation of mass, momentum, and energy. A field model still requires input data. "If you tell us how much smoke and heat a fire produces, we'll tell you where the smoke and heat will go and how fast," Baum says.

While Rehm and Baum work on idealized fires, Quintiere uses a model developed for a more realistic fire. Quintiere questioned whether people would pass out or even die from carbon monoxide produced when materials smolder before bursting into flames.

The answer: yes, depending on the material smoldering and the size of the room. Quintiere used a zone model developed by Edward Zukoski of the California Institute of Technology. The model used data found in laboratory tests conducted by the NBS toxicology group headed by Merritt Birky. Those results were used both to generate data for the model and to confirm its predictions.

Getting Out Safely

Just down the hall from Quintiere, Leonard Cooper wants to know how long people have to get out of a burning building. Cooper talks about "safe egress," that is, the time you have to get out before a room becomes hazardous. That varies from room to room and from building to building. To run laboratory tests on each is impossible, Cooper notes.

To begin to solve the problem, Cooper used fire growth curves from test data on "cribs" (stacks of wood sticks), mattresses, and warehouse cartons, all plotted against time, to "build" a standard fire. He defined "hazardous" as a smoke layer which had descended from the ceiling to 90 centimeters above the floor or a room temperature of 183 °C, whichever came first. He then used the standard fire and modeled how long it took rooms of different sizes to become hazardous.

For a 230 square meter (2,500 square foot) auditorium, for example, the answer was 5 to 6 minutes, depending on when the fire was detected and the alarm given. It took 7 to 8 minutes for a 650 square meter (7,000 square foot) warehouse and 2 to 3 minutes for a 37 square meter (400 square foot) bedroom. "For the latter two, that should be

enough time for you to get out safely if you were awake and able," Cooper says, "but in the auditorium your safety would depend on the number of exits and the behavior of others."

In all of these rooms, Cooper assumes that people can get out. But what if they can't? In a prison, for example, it may take too long to get prisoners out of their cells. The problem here becomes one of making rooms safe during a fire rather than getting people out in time.

To solve this problem, Cooper built four prototype cells based on those in maximum security prisons in Baltimore, Md., and Lorton, Va. Each cell measured 165 centimeters wide by 275 centimeters deep by 245 centimeters high. Only their doors differed, ranging from full, open bars to a solid door with only a window at the top and an undercut at the bottom. Laboratory tests showed that a fire inside the cell burned faster and produced more smoke in the former because open doors feed more oxygen to the fire. In cells with solid doors, fires burned longer but at a slower rate.

With these results, Cooper put the data into a model and added fans to pull potentially dangerous smoke out of the cell block. But how big a fan would be needed for each cell block? For a four-tier cell block, the answer ranged from one capable of moving 850 cubic meters (30,000 cubic feet) of air per minute for cells with solid doors to 2000 cubic meters (70,000 cubic feet), for those with fully open doors with bars. The fans would be mounted near the roof of the big cell block buildings. For this system to work, Cooper cautions, there must be openings at the bottom level to allow air into the cell block.*

Like Quintiere and Cooper, Rockett also uses zone models. Rockett hopes that better fire standards and tests develop from modeling. Most fire standards today, he says, are based on experience and subjective judgment. "Building codes presume that we know how to build safe buildings," Rockett states. "But I don't know that test methods actually relate to a real fire hazard."

Rockett's current work shows the limited state of fire modeling in 1981. He uses a model developed at Harvard University to predict heat given off by a burning polyurethane, twin-bed mattress like those used in nursing homes and hospitals. When Rockett compared his results with those from laboratory tests, the model predicted ceiling temperatures of gases produced by the fire to be 435 °C while laboratory tests showed them to be 535 °C.

"Some say that getting within 100 °C is a success for modeling," Rockett says. "But I won't be satisfied until I know why the model is underestimating the temperature."

The Work Continues

Remarkable progress has been made in modeling in less than a decade, but, as Rockett says, "we have work to do." And work continues. At NBS, Takeyoshi Tanaka (a visiting scientist from the Japanese Building Research Institute) is developing a model to predict heat and gas flow from a fire in a large building. The model currently examines a 25-room building, 5 rooms on a floor plus 2 stairwells. The model is limited to heat flow due to fire rather than forced ventilation effects. Preliminary results demonstrate the future potential for predicting fire growth in real buildings.

Indeed, Harvard scientists led by Howard Emmons are working under an NBS grant to model fire spread from one room to adjacent ones. Smoke spread can already be modeled, but not fire. This work will extend previous NBS-supported research that modeled fire growth in one room.

Based on these and other research efforts, Quintiere expects that within 5 years the reliability of room fire models will be more firmly established and their applications should increase. The replacement of standards with modeling or the interfacing of modeling and test method will take longer to achieve.

To reach that point, modelers will need to better understand fire plumes, the spread of heat and flames from the burning material (fire source), and the mixing of heat and smoke between the upper and lower levels in a room. The latter is not even included in some models yet, Quintiere says, adding: "Some of these issues should be resolved in the next few years."

Rockett agrees. "A model is like an analytic system," he says, summing up 2 decades of fire modeling. "It is not cast in the correct form yet, but we're getting there." Once it is, Rockett foresees benefits for architects, structural engineers, fire inspectors, building code officials, and other fire practitioners. "Just like a bridge is designed not to collapse in an unexpected way, so, too, you don't want a building to burn in an unexpected way," Rockett says. "That's the next step for modeling." □

**Cooper's approach on smoke control in prison cell blocks has been adopted by the National Fire Protection Association as an option in its Life Safety Code.*

A BLUEPRINT FOR THE

NBS plans for

The following article is excerpted from the second long-range plan of the National Bureau of Standards. The Bureau's long-range plan is a strategic plan, not an implementation plan or a budget document. It is intended to provide guidance from the NBS director to the staff as well as to inform outside observers—including industrial, academic, and Government users of NBS research and services—about the Bureau's perceptions of its future. The portion of the plan presented here identifies the Bureau's programmatic themes and discusses areas of emphasis. This plan was prepared by the NBS Planning Office; any comments or suggestions should be directed to Kenneth Gordon, director of the Planning Office, or Elaine Bunten-Mines, analyst, at A929 Administration Building, National Bureau of Standards, Washington, DC 20234, 301/921-3872.

FOR 80 years, the National Bureau of Standards has been known for scientific and engineering excellence, for integrity, and for impartiality. This is a reputation to be proud of, but one that wasn't acquired overnight. It comes from hard work, enlightened research, and the foresight to plan ahead. Scientists and engineers from industry, academia, and Government alike realize that research is too expensive and too important to the Nation's well-being to be entered into without focus and direction. Moreover, the best science and technology research doesn't follow today's trends, it anticipates tomorrow's.

Several years ago, the Bureau started to be concerned with identifying important scientific and technological needs and directions. This long range plan is a continuation of that initial effort. It highlights the national trends and technical challenges that will drive our future programs and outlines the programmatic themes that the Bureau will pursue 5 to 10 years in the future.

The five major thrusts of the Bureau that will continue or grow in importance in future years are:

- Basic measurements and standards;
- Support to industrial productivity and innovation;
- Advanced materials for substitution and displacement;
- Support for energy development and use; and
- Enhanced Federal information processing.

The basic measurement area is the Bureau's unique assignment. The others are important national problem areas that are heavily dependent on science and technology for solutions and, in particular, are dependent on the kinds of technical infrastructure services that NBS provides. These program thrusts have been and will continue to be developed within the context of broader national economic objectives and policies.

Basic Measurements and Standards

Standards and measurement programs are carried out at the National Bureau of Standards to advance economic development, foster equity in trade, promote public health and safety, and provide U.S. science and technology with a measurement base that is accurate and consistent with that maintained by other nations. This responsibility requires continuous refinement and dissemination of the standards of physical measurement. The scope of these standards and measurement programs is determined by the nature of measurements made throughout commerce, industry, science, and Government and reflects the specific needs of these broad public and

FUTURE

the years ahead

private sectors. Such measurements require standards in all areas of physical measurement. Uniform and reliable physical measurements require that the measurement of the same quantity, wherever it is made, will always yield the same result within an acceptable level of accuracy. The only practical method for realizing uniform and reliable physical measurements is for NBS to provide national reference standards and services that are conveniently available at a reasonable cost.

The vast majority of physical measurements made in the United States, and worldwide, may be defined in terms of a few physical quantities. By international agreement, certain fundamental physical quantities have been identified as forming the basis for measurements of other physical properties and phenomena. These fundamental physical quantities (and their units, called base units) are time (second), length (meter), mass (kilogram), temperature (kelvin), and electrical current (ampere). The ability to measure other physical quantities, such as speed, energy, or concentrations of pollutants in the atmosphere, depends on the accuracy with which the units of the fundamental quantities can be maintained and disseminated. Certain other physical quantities such as the speed of light and the electrical charge of an electron are constants of nature and their accurate determination is essential for the derivation of practical units of measurement from the base units, which in turn find direct applications in science and technology.

NBS has a continuing mission to develop and to use new science to make fundamental physical measurements and standards more accurate and easily maintained and to develop new ways to transfer these standards to the field. Improved measurements and standards are needed in almost all manufacturing industries because of the universal application of measurement to materials and processes. NBS is proceeding with its efforts to define measurement standards in terms of more intrinsic relationships of fundamental constants that are feasible for field use. Future research thrusts in the physical standards area include:

The standards and measurement programs comprise a major area of the Bureau. Here, research chemist Jeanice Brown-Thomas prepares a batch of shale oil samples for certification as Standard Reference Materials. SRM's are well characterized materials with chemical or physical properties certified by NBS, which can be used by other scientists to calibrate measurement methods or instruments.

- Development of improved time standards to meet the growing needs in navigation and communication;
- Investigation and measurement of ionizing radiation and its effects leading to improved personal dosimetry measurement devices;
- Investigation of the quantized Klitzing effect on electrical resistance as an improved, invariant standard for the ohm;
- Development of self-calibrating optical radiation measurement techniques that are detector-based to complement present ineffective source-based methods;
- Development of methods that can be used for dynamic measurements of rapidly varying pressure and temperature; and
- Investigation of methods that can be used to better measure the properties of ionized plasmas for diagnostic and calibration purposes.

In chemical measurements and standards, as in other fields, NBS provides services in essentially two different modes: (1) broad infrastructure services to a wide range of industries applying chemistry for the manufacture of goods or the delivery of services; and (2) narrowly focused research and development work to help solve specific problems of national significance.

NBS infrastructure services are directed toward the needs of the traditional chemical and petrochemical sectors (with annual sales of $150 billion) and the whole spectrum of other industries and organizations that apply chemistry to their purposes. This includes the electronics and semiconductor industries; utilities; instrument makers; manufacturers of steel, rubber, and plastics; plant fabricators; manufacturers of equipment, pipe lines, and transportation; and the health industry. It also includes governmental organizations dealing with environmental pollution, toxic substances, and medical services.

The chemical process industry alone consists of more than 125,000 companies, less than 3,500 of which have more than 100 employees. This kind of disaggregation in the firms and industries that use and depend on chemistry has led over the years to the gradual creation of a complex chemical measurement system. The scope and complexity of this chemical measurement system requires the involvement of a variety of contributors: The metrology laboratories, analytical and quality assurance laboratories of the affected industries, many companies specializing in analysis and metrology, the manufacturers of measurement instrumentation, State and local Government laboratories, and professional organizations. NBS is at the hub of this system. NBS provides measurements related to the fundamental units of measurement with the highest level of accuracy, gives guidance and expert advice, and acts as a neutral third party.

In the near-to-mid-term future, NBS infrastructure services will continue to focus on measurements and standards related to the fundamental design of chemical processes that are common to many industries. Emphasis will be on providing data, measurement methods, and understanding that will allow industrial researchers and engineers to tailor specific process improvements to existing systems. Areas of emphasis include the prediction of thermochemical and thermophysical properties, physical and chemical properties and reaction pathways of substances in aqueous solution, and improved measurement techniques for unit operations and chemistry, and unit operations and processes.

In the longer-term, significant changes are expected in the chemical-based industries (for example, materials substitution, shifts to biomass, use of enzymes for bulk chemical production, and increased emphasis on safe waste disposal). NBS programs in support of these longer-term needs will emphasize the development of competency in the areas of quantum chemistry of complex systems, surface physics and chemistry, and the interaction of ionizing radiation with matter.

Improvements to Industrial Innovation and Productivity Growth

Most NBS programs are designed to support industry and commerce. By maintaining and disseminating the national measurement standards, by providing chemical data, and by studying the basic properties and structure of materials, NBS supports industrial productivity and innovation. In recent years, NBS has also initiated and expanded programs to contribute more directly to the support of productivity growth and innovation in certain key industrial technologies. Subjects that will be receiving increased emphasis in the future are manufacturing automation, advanced materials, electronics (including optoelectronics), chemical process technology, and construction.

In the area of automated design and manufacturing, the lack of productivity growth and subsequent poor performance of many U.S. manufacturing industries can be directly related to their failure to adopt modern technologies. In manufacturing, large

future productivity gains will come from automation. NBS currently has underway a major expansion of programs related to automation and advanced manufacturing technologies. The Bureau is establishing an automated manufacturing cell or work station that will be used for the development and testing of the standards and metrology needed for the adoption of automation technology by the discrete-parts manufacturing industries. Industry will participate extensively through industrial research associates, conferences, workshops, and symposia.

The U.S. economy has tremendous needs for advanced materials such as raw plastics, metals, ceramics, and solid state compounds. New materials that are stronger, lighter, easier to shape, more corrosion-resistant, more durable, and less energy-consuming will be needed to facilitate higher rates of technological innovation and increased productivity. By combining new production processes with new materials, additional productivity advances can be achieved.

Major future thrusts will include measurement technology needed to produce bulk materials economically in desired shapes and with desired characteristics (such as by rapid solidification), data and models to help understand new, high-performance materials, and measurement techniques needed for the study and control of corrosion and fracture.

A third major area of future emphasis is electronics. An ongoing major research thrust for NBS is in very large-scale integrated (VLSI) circuits. The rapid development of this technology in the last 2 decades has revolutionized information storage and processing. Higher levels of integration have been achieved principally by making the individual circuit elements smaller, but reduction of random defects and innovations in circuit design have also been important factors in rapid productivity growth.

The potential for even greater gains in productivity is indicated by the explosive growth in devices based on microprocessors. However, to capture these potential gains, U.S. firms will require a large and sustained research program to overcome a number of significant technological barriers. Some of these barriers have major measurement, test method, and data components that can be most effectively addressed by NBS. NBS programs will address a range of measurement-related problems, including the understanding and control of crystal defects and materials interfaces, process controls and monitors, test procedures for very large and complex circuits, and understanding of the packaging process used to encapsulate integrated circuits.

Much of the work of the Bureau focuses on improving industrial productivity. Physicist Gary Carver inserts a semiconductor wafer containing solid state imagers into a test station. By testing integrated-gated diode electrometers incorporated in each imager chip, Carver is able to quickly and easily determine materials-related properties that affect the electrical quality of the devices. The result: better quality devices with less materials waste.

In addition to the major thrust in VLSI metrology, the electronics program includes separate productivity-related efforts aimed at developing needed metrology for emerging technologies such as fiber optics, optoelectronics, and automatic test equipment.

A fourth area of productivity-related programs to be emphasized by NBS is chemical process technology. The American chemical industry is facing a changing environment that will require increased innovation and capital investments in the next decade if the industry is to remain competitive in world markets. NBS will support the innovation process by providing advanced measurement and analysis methods, data, and models for the design and control of new processes, and reference materials for production and quality control. The near-term NBS emphasis will be on building a technical information base for coal chemistry in a wide variety of applications and on providing advanced analytical methods for high technology industries. In the longer term, emphasis will shift to providing technical understanding for more energy-efficient catalytic processes and for the use of biomass as chemical feedstock. Specific areas of activity will include advanced analytical metrology, the chemistry and structure of interfaces, multicomponent analysis and compositional mapping, enzyme catalysis, and the structure and chemistry of aromatic compounds.

The final area of productivity-related NBS programs is in support of the U.S. construction industry. New construction accounts for more than 10 percent of the Gross National Product, but the industry is highly fragmented. This market structure makes it particularly appropriate for Government to participate directly in nonproprietary research and development that will lead to productivity gains throughout the industry.

Future NBS programs will undertake research to develop information on construction loadings, especially the load factors that relate to the pouring and curing of concrete, and methods for predicting potential failures in major building components.

Advanced Materials for Displacement and Substitution

Materials technologies are of central importance to high productivity in manufacturing, new energy sources, efficient and safe transportation systems, and, in general, healthy industrial growth in the United States. For a large fraction of essential manufacturing materials, the United States is dependent on overseas sources. Many of these sources are subject to sudden disruption. Supply cutoffs and price escalation are a continuing threat to American economic stability.

National leaders are considering the best mechanisms for dealing with the problem of growing U.S. dependence on overseas sources of critically needed materials. Major alternative responses are to ensure stable supplies by stockpiling, to increase domestic production, or to improve source stability through foreign policy initiatives. Another alternative is to minimize dependence on imports by promoting advances in materials science and technology. A particularly attractive approach is to foster research and development in improved or new materials which will perform desired functions with a minimum of imported critical materials. These efforts can result in new higher performance materials that can displace existing critical materials without economic penalty. Such research also adds to the "intellectual stockpile" of basic information about structure, properties, and processing that can be used to facilitate the introduction of substitute materials in a supply emergency. A significant portion of the NBS materials program will focus on providing a needed technical base for a substitution and displacement strategy for reducing U.S. vulnerability to critical materials supply interruptions.

The successful introduction of advanced high-performance substitute and displacement materials also has important implications for productivity enhancement. For example, polymer composites are promising candidates for reducing the weight, and thus the energy (fuel) demand, of transportation equipment. Composites, if introduced successfully in the transportation equipment market, would also displace and significantly reduce demand for manganese (in steel) and for aluminum alloys. Both of these are heavily imported critical materials.

Future NBS efforts in this area will provide technical data on material properties and processing parameters to support the private sector in its efforts to develop and commercialize advanced materials that have potential as alternative sources for critical, imported materials. Areas of emphasis will include ceramic composites, high performance ceramics (good potential for use in automobile gas turbines), metal alloy coatings (attractive for use in existing production processes), rapid solidification technologies (great potential for creating unique and useful properties), and innovative materials such as thin films, glassy metals, ionic conductors, and amorphous materials.

Technological Support to Energy Development

The assurance of adequate energy for the Nation is a major concern of the Federal Government. NBS, in carrying out its measurement and standards function, conducts research programs in support of that goal. Foreign supplies of oil, upon which we are heavily dependent, are becoming increasingly uncertain and expensive, and domestic requirements for fuels will continue to rise. New energy technologies both for conservation and for developing new supplies are emerging, with corollary requirements for new measurement technology.

NBS long-range plans call for substantial levels of effort both for the development of energy supplies and for the effective implementation of energy conservation. Although the nature and composition of the research will change in the future as needs change, energy research will remain a major thrust for NBS. The total NBS effort in this area now includes projects specifically addressed to energy problems (e.g., energy conservation in buildings and combustion efficiency of industrial furnaces). These programs are almost entirely supported with funding transferred from the Department of Energy (DOE). Other NBS activities, which are broader in scope and relate to energy problems only indirectly (e.g., work on corrosion), are primarily supported with funds appropriated directly to NBS to carry out its measurements and standards mission.

Since DOE is the lead agency in Federal energy programs, DOE program priorities will continue to be important to NBS. The size of the NBS effort in support of DOE (nearly $20 million in fiscal year 1980), the measurement-sensitive nature of new and proposed energy programs, and the expected shift in DOE's priorities will all have implications for the Bureau. NBS involvement in energy research grew significantly during the 1970's, but the future magnitude of this work is uncertain as shifts in national energy policy are made. In the future, NBS programs are expected to continue to focus on problems of efficient use of energy in industry and in buildings as well as address a wide range of measurement needs related to energy conversion and supply technologies. Increased emphasis will be placed on measurement problems of the chemical process and synfuel industries.

Enhanced Federal Information Processing

The development of computers, and the subsequent revolutionary growth of the "information industries," is clearly one of the most significant trends in American economic development in the past half-century. The Federal Government, as one of the largest users of information technology and as one of the largest producers and users of information, is greatly affected by changes in computer technology and, conversely, can significantly affect the evolution of the technology. NBS has a major program aimed at one aspect of the information processing revolution: Improved procurement and utilization of computers within the Federal Government. This area will remain a strategic direction for NBS in the future. There are specific areas where additional technical activities are in great demand and where NBS can make significant contributions.

The Federal Government, one of the earliest computer users, has become the world's largest. Recordkeeping requirements for Government programs and services such as health, defense, veteran's benefits, tax administration, and weather have increased tremendously over the past 35 years. According to the General Services Administration, in 1979 the Federal Government operated 14,984 computer systems whose total value exceeded $5 billion.

Effective management of these important resources is essential because of the size and complexity of Federal ADP operations and the dependence on computers for vital and sensitive functions. Federal data processing operations and services cost billions of dollars annually and have been studied by executive, legislative, and private sector organizations. Many studies have identified serious problems in the Government's use of ADP, including obsolete equipment, cumbersome procurement procedures, costly software development, and weak management and planning.

To help Federal agencies protect the integrity of their data, NBS computer scientist Stuart Katzke has prepared a guideline based on risk management and software development techniques that will improve security of funds dispersing, inventory control, and other computer application systems.

NBS technical activities in computer science and technology are aimed at helping Federal agencies improve ADP management and effectively use new technology. The Brooks Act (P.L. 89-306) authorizes the Secretary of Commerce (delegated to NBS): (1) to provide agencies, and the Administrator of the General Services Administration, with scientific and technological advisory services relating to automatic data processing and related systems; (2) to make appropriate recommendation to the President relating to the establishment of uniform Federal automatic data processing standards; and (3) to undertake the necessary research in the sciences and technologies of automatic data processing, computer, and related systems, as may be required to perform the other functions.

For the past several years, the Bureau's principal effort has been devoted to only one of the three responsibilities—the development of Federal automatic data processing (ADP) standards. Federal needs for standards and guidelines have been identified by the Congress, the Office of Management and Budget, the Federal agencies, and NBS. Future NBS emphasis will be on Federal Information Processing Standards (FIPS) that can improve Federal agency management of computers in four broad areas: improving the effectiveness and productivity of software development, improving the use of database systems and the representation of data, providing a quantitative technical basis for evaluating and controlling day-to-day computer operations, and providing computer interface standards to allow competitive procurement. While the ADP standard's focus is a very high priority activity, it is clear that carefully selected activities in advisory services and supporting research would enhance progress toward the overall goal of improved procurement and utilization of computers by the Federal Government. □

A Faraday Keeps the Doctors Astray

by Michael Baum

New Results on Atomic Weight of Silver

THIS past spring, after some agonizingly careful chemistry, three NBS research chemists announced the results of their project to measure the atomic weight of silver—to the unprecedented accuracy, for an element with equal atom composition, of nearly a part in a million.

Who could possibly use information like that? Not precious metal dealers or alloy chemists, but a group of physicists working two-flights-up and down-the-hall. They needed the number because *they* were working on a new determination of the Faraday.

The Faraday is one of the "fundamental constants," a collection of basic physical values ranging from familiar concepts like the speed of light to more arcane ones, like the Rydberg constant of spectroscopy, or the Compton wavelengths of elementary particles. Together they define the physical characteristics of our universe. An impressive, and international, assortment of physicists and chemists works at improving our knowledge of the values of these fundamental constants.

In part, this work simply reflects scientific aesthetics, what scientists such as Barry Taylor of the NBS Center for Absolute Physical Quantities refer to as "the romance of the next decimal place." But, notes Taylor, there are some very practical reasons behind this essentially endless pursuit of precision. For one thing, the fundamental constants are the values that tie physicists' theories to the physical world. If an inconsistency were found, for example, in the theorems of quantum electrodynamics, it would probably show up in measurements of the fundamental constants.

Such experiments often lead to the development of new measurement techniques that find wide application in other branches of science, and, of course, there are fields where extremely accurate values for the constants are important in their own right—nuclear fusion studies, for example.

The Faraday is an interesting case because for several years now, the fundamental constants community has been in something of a quandry over the Faraday.

Electrifying News

In 1833, an ex-bookbinder named Michael Faraday published his two laws of electrolysis, chemical reactions that take place in the presence of electric current. One of the first to study electrolysis quantitatively, Faraday found:

1) The amount of electricity needed to decompose a chemical by electrolysis is directly proportional to the amount of chemical decomposed.

2) The amounts of substance decomposed for two different chemicals are always in the same ratio as the valences of the two chemicals. (Valence is a quantitative measure of one chemical's ability to combine with others; it is related to the positions and energy levels of the element's electrons.)

Faraday's studies led to some fairly important conclusions—for one, they implied that, like material substances, electricity is composed of atom-like particles. These came to be called electrons.

The constant named after Faraday relates the amount of electricity used in the chemical reaction to the amount of substance reacted.

The most straightforward way to calculate the Faraday goes like this: Call the quantity of elec-

Baum is a writer and public information specialist in the NBS Public Information Division.

tricity that flows in a 1 ampere current for 1 second a *coulomb*. Set up an electrolysis experiment and measure the amount of substance either dissolved or deposited on the electrode (depending on the experiment) by one coulomb of electricity. Call this mass the *electrochemical equivalent* of the substance. Divide the molecular weight of the substances by its valences (silver has a valence of one), and call this mass the *chemical equivalent* of the substance. Then the Faraday is equal to the chemical equivalent divided by the electrochemical equivalent, and it represents the amount of electric charge needed to electrochemically react one chemical equivalent of substance. If the substance has a valence of one, then the chemical equivalent is equal to the molecular weight, and the Faraday is measured in coulombs per mole.

There are other ways to get the Faraday. For example, it is equal to the elementary charge, e, times Avogadro's constant, which is the number of molecules (or atoms) in a molecular weight (or atomic weight). It is also equal to the rather involved expression:

$$F = \frac{\gamma_p\,(\mathrm{low}) \cdot M_p}{\mu_p/\mu_N \cdot K^2}$$

Here M_p is the atomic mass of the proton, γ_p (low) is the proton gyromagnetic ratio measured by the so-called low field method, μ_p/μ_N is the proton magnetic moment measured in nuclear magnetons, and K is the ratio of the ampere standard used in the experiment to the ideal System Internationale (SI) ampere.

These equations help explain the interest physicists have in making ever more accurate measurements of the Faraday. An experimental value of the Faraday can be used to check the accuracy of the values used for the other constants and the theory behind them. A particularly important value is K, the ratio of the "as-maintained" ampere to the SI ampere. (Each national standards laboratory maintains an "ampere" standard by one device or another. Usually it is calculated from the laboratory's as-maintained standard volt and standard of resistance. The actual SI definition of the ampere, involving as it does infinitely long, infinitely thin wires, is not practical for daily use.)

Faraday?

Of course, experimental measurements of other fundamental constants play a part in checking the value of the Faraday, too. Over the past decade, this has occasioned a certain amount of discussion. One of the most influential approaches to the systematic study of the fundamental constants is the so-called "least squares" adjustment, which was started in the 1920's. A "least squares" adjustment is a statistical procedure in which the best experimental values and theoretical calculations of the various fundamental constants are combined, with due regard for the estimated uncertainties of the measurements, and used to calculate a set of values for the constants that is self-consistent and reasonably in agreement with the experimental data.

In 1969, a major least squares calculation of these constants had to deal with five separate experiments to measure the proton magnetic moment, the results of which seemed to be basically divided between two different values. On the strength of a separate measurement of the Faraday in 1960 (by D. Norman Craig and others at NBS), the two higher values were thrown out in favor of the three lower values and the Faraday experiment.

By 1973, there was new evidence that suggested that the higher value for the proton magnetic moment was correct after all, implying that Craig's value for the Faraday was too high. The new least squares adjustment recommended a significantly lower value for the Faraday. (The numbers were—Craig: 96486.72 C/mol., least squares adjustment: 96484.49 C/mol.)*

In the meantime, other experiments had been done to measure the Faraday. Craig and his colleagues had used a classic silver coulometer, or electrolytic cell, but other experiments used the electrolytic reaction of a variety of (usually) organic reagents, including benzoic acid, oxalic acid, and 4-aminopyridine. A pattern began to form. With the exception of the last of these experiments (reported in 1976), the electrochemical measurements of the Faraday tended to cluster between 96486 and 96487 C/mol.

The discrepancy suggested that a fairly important error had been overlooked somewhere in the system, and suspicion now fell on the measurement of the as-maintained ampere and on the measurement of the Avogadro constant. But for almost all

**The actual numbers for these values vary slightly depending on the particular "ampere" used. There are, for example, the ampere as maintained by NBS, the ampere as maintained by the BIPM (the International Bureau of Weights and Measures), and the ideal System Internationale ampere. For consistency, all of the Faraday values cited in this article are in terms of the BI69 ampere—the international ampere as maintained in 1969.*

of these experiments, the estimated range of experimental error was so large (see Figure 1) that it was difficult to determine just how serious the discrepancy was. Obviously, what was needed was a new, extremely precise measurement of the Faraday.

Back to Silver

To accomplish this, NBS physicists Richard Davis and Vincent Bower returned to the silver coulometer experiment used by Craig and his coworkers, with some important changes.

In the basic experiment, a bar of high purity silver is used as the anode. Davis and Bower used a rod of extremely pure silver of the same type that is used by NBS as a Standard Reference Material. Platinum is used for the cathode, and a solution of perchloric acid in water is used as the electrolyte. (A small amount of silver oxide is added to the electrolyte to reduce whatever tendency the silver anode might have to dissolve in the solution.)

Standard volt cells and resistors are used to produce a very accurately known electric current, which is passed through the coulometer for a carefully measured period of time. Under the action of the current, the metallic silver of the anode dissociates into silver ions and electrons, one silver ion for each electron. The silver anode is weighed carefully before and after electrolysis to determine the amount of silver electrolyzed.

One of the most important experimental uncertainties in this set-up is the presence of what is sometimes called "anode sludge." As the silver in the anode dissociates under the action of the current, particles of fine silver dust inevitably break free and fall to the bottom of the cell. Since the silver in this "sludge" does not take part in the reaction, it must somehow be accounted for in the final weighing.

Research chemist Lura Powell at mass spectrometer.

Accurate measurement of this residual silver has always been something of a problem in the silver coulometer experiment. In previous experiments, the silver was recovered, filtered, weighed, and counted in the final weight of the anode. Weighing such a small quantity in the much heavier filter crucible introduced fairly serious errors, however. To avoid this, Davis and Bower developed a procedure in which the silver residue is washed, converted to silver nitrate, and analyzed for silver content by controlled potential coulometry—essentially the reverse of the reaction used in the experiment. Using this technique, they were able to measure the residue well enough to achieve an accuracy of about 0.6 ppm in the overall experiment.

The result of the experiments by Davis and Bower was a value for the electrochemical equivalent of silver accurate to within 1.28 parts per million:* Five times more accurate than the best previous silver experiment, more than twice as accurate as the previously determined least squares approximation of the Faraday.

Davis and Bower had achieved a striking improvement in the measurement of the electrochemical equivalent of silver. But that was only half of the problem. The best available data on the atomic weight of silver was from work done 20 years before at NBS. With an uncertainty of 2.1 ppm, this factor had become the dominant uncertainty in the electrochemical determination of the Faraday.

Research chemists Lura Powell, Thomas Murphy, and John Gramlich set to work on the atomic weight of silver. What they were after was essentially the most accurate measurement ever made of the atomic weight of a multinuclidic element with equal-atom

**Customs differ in the reporting of errors. In much of the experimental community (including those who measure atomic weights), the practice is to report an estimated error equal to twice the standard deviation of the test results, or "at the 95 percent confidence level." In the fundamental constants research community, it is common to assign an error equal to one standard deviation, or a "68 percent confidence level." (If you run the experiment 100 times, 68 times the result will be within the error limits of the original figure.) In this article, all errors (except those of atomic weight) are reported for one standard deviation. Without exception, however, errors are quadratically combined at a level of one standard deviation.*

isotopic composition. The procedure is fairly straightforward, the trick is to do the experiment at extremely high levels of accuracy and precision.

A key procedure in the experiment is the calibration of the mass spectrometer used to measure the relative concentrations of isotopes in the silver sample. Adding the isotopic weights in the proper ratio then yields the atomic weight of the element. Silver has two naturally occurring isotopes, ^{107}Ag and ^{109}Ag, which are found in nearly equal proportions. Murphy developed a high precision chemical assay procedure and used extremely pure samples of the isotopes, provided by the Oak Ridge National Laboratory, to prepare a series of "synthetic" silvers of known concentrations for the calibration process.

Working with a sample of the same silver used in the Davis-Bower experiment, Powell and Gramlich did the mass spectroscopy work to measure the silver isotope ratios.

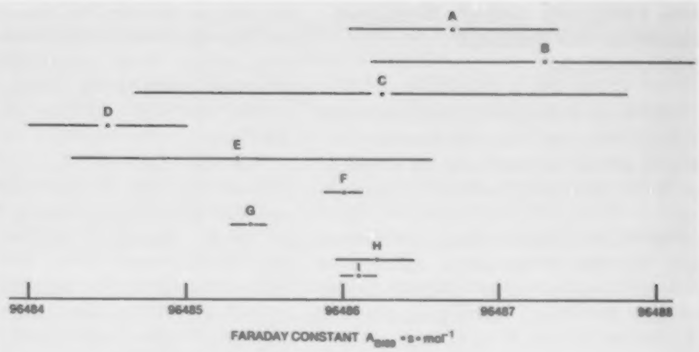
(Analytical chemists will be interested to know that Powell and Gramlich adapted the so-called "single filament silica gel" technique to ionize the silver sample in the mass spectrometer. This is believed to be the first application of this technique to extremely high precision mass spectrometry. The name refers to the method of preparing the filament used to vaporize and ionize the silver in the spectrometer.)

The work paid off in a new value for the atomic weight of silver believed accurate to nearly a part in a million, about 10 times more accurate than the best previous value. (The value, incidentally, is 107.86815 +/- 0.00011.)

Back to the Lab

Multiplying and dividing as appropriate, we can calculate a new value for the Faraday, accurate to about 1.3 parts in a million: 96486.06 C/mol., considerably closer to the 1960 experimental value for the Faraday than to the value recommended by the 1973 least squares adjustment. More importantly, the estimated error for the new value is much smaller than the errors involved in those previous Faradays, which emphasizes an apparently very real discrepancy in the results.

Further research will be necessary to straighten it all out. One important experiment, according to Taylor, is a new effort to measure K, the ratio between the ampere as maintained at NBS and the ideal SI ampere. An error in that value would affect an experiment which involves a translation from



The results, when converted to BI69 electrical units, yield the following for the Faraday constant:

A. 96486.72 $A_{BI69} \cdot s \cdot mol^{-1}$ (6.8 ppm), Craig's silver determination, 1960
B. 96487.30 (11.6 ppm), Marinenko and Taylor, benzoic acid 1968
C. 96486.25 (16.3 ppm), Same authors oxalic acid 1968
D. 96484.49 (5.2 ppm), Recommended value based on physical constants, Cohen and Taylor 1973
E. 96485.37 (11.2 ppm), Koch and Diehl, 4-aminopyridine 1976
F. 96486.00 (1.1 ppm), Kibble and Hunt, proton gyromagnetic ratio
G. 96485.40 (1.1 ppm), Deslattes et. al., Avogadro constant
H. 96486.21 (2.5 ppm), Davis and Bower, original experiment
I. 96486.06 (1.4 ppm), Davis and Bower using new silver atomic weight

Figure 1—*The results of various attempts to determine the value of the Faraday. The lines to either side of the graph points show the estimated error for each point. The lowest point (D) is the 1973 value for the Faraday as calculated by the "least squares" approach. Values (H) and (I) are, respectively, the result of Richard Davis' and Vincent Bower's experiment as reported in 1980, and the same result modified to take into account the new determination of the atomic weight of silver.*

experimental figures to the SI ideal. The "absolute ampere" experiment is now being conducted by physicists P. Thomas Olsen, William Phillips, and Edwin Williams at the NBS non-magnetic laboratory, and a preliminary result is expected in about a year.

Another possibility under examination, according to Taylor, is that there may be a small error in the density scale used by NBS, which involves, among other things, a very difficult measurement of the true diameters of a set of steel reference balls. Any error in the density scale would have been incorporated into the experimental value for Avogadro's constant determined in 1974 by NBS physicist Richard Deslattes and colleagues, a value that is also inconsistent with the recent Faraday experiment.

All of which, Taylor notes, bears out the sense of a favorite quotation of his from a well-known physicist:

Why should one wish to make measurements with ever increasing precision?

Because the whole history of physics proves that a new discovery is quite likely to be found lurking in the next decimal place.

F.K. Richtmyer, 1931

Watch this space for future developments. □

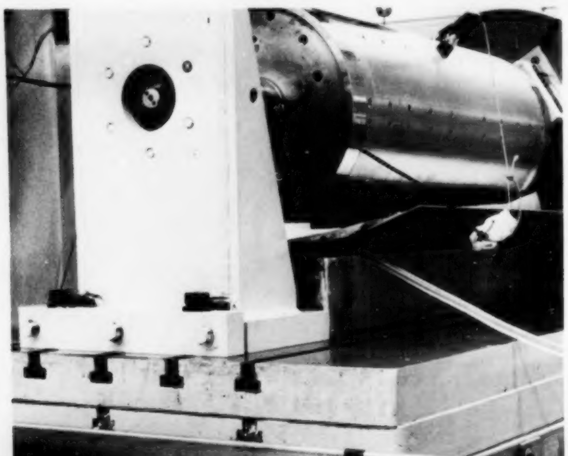
NBS DEVELOPS CHEAP, EFFECTIVE METHOD TO PREDICT DRILL FAILURE

NBS research engineers have developed a cheap, effective device for detecting improper drilling or predicting the failure of small drill bits used in automated machining.

The microprocessor-based instrument uses time-domain analysis of signals from a simple accelerometer attached to the workpiece to detect warning signs of improper drilling (resulting in large or out-of-round holes) and drill failure just prior to the actual breakage of the drill.

This device is a by-product of an effort at NBS to develop the theoretical basis and the experimental techniques to relate the surface finish and dimensions of machined parts to the vibration patterns of the machine tool that manufactures the parts.

The new "Drill-Up" was developed by Kenneth Yee and Donald Blomquist for use with numerical control machine tools or similar automated systems that are working with comparatively small drill bits, approximately ⅛-inch diameter or less, according to NBS project manager Donald Blomquist. Such small drill bits, backed by the enormous forces exerted by modern machine tools, can drill out-of-round holes and are prone to break. Because of a variety of complex factors, such as sharpness, tool geometry, and inconsistencies in the workpiece, it is difficult to predict just when a bit will improperly drill or break. The consequences can be expensive, particularly with automated machinery, which often is unsupervised.



Prototype "Drill-Up" (foreground) was designed with an LCD meter to aid researchers in checking the performance of the device. Vibrations in the workpiece (background) are detected by a standard accelerometer magnetically attached to the workpiece.

In the new NBS device, a small inexpensive microprocessor is used to analyze the signal from an accelerometer which is attached magnetically to the surface of the workpiece. The instrument registers the normal amplitude of the signal from the accelerometer as the drill bit enters, bores, and withdraws from the workpiece. At the same time, it monitors the signal for peaks that exceed 400 percent of the normal signal amplitude. When such a peak is found, the instrument tests whether or not the same peak is observed four times in a row with a periodicity equivalent to the rotation rate of the bit. If it does register this peaking, the instrument sends a signal to the machine control unit to halt the drilling.

"The requirement that an excessive signal peak must recur four times in a row within the proper time interval reduces the number of 'false alarms' caused by random shocks to the workpiece," according to Blomquist.

"In trials," Blomquist added, "the monitoring device successfully predicted drill-bit failure 49 out of 50 times." In soft steels without lubrication, the average period between prediction and breakage was about 10 holes; in hard steels, the period averaged between 2 and 5 holes.

A major advantage of the new device is that it is comparatively inexpensive to produce—perhaps $300-$400 per unit. Present-day equipment for predicting small drill failure generally relies on complex signal-processing techniques such as Fast Fourier Transforms and expensive computing equipment which are too expensive to be used on a production basis.

Further details on the new device are available from Donald S. Blomquist, Automated Production Technology Division, Center for Manufacturing Engineering, National Bureau of Standards, Washington, DC 20234. Telephone 301/921-3381. M.B.

STAFF REPORTS

NEW METHOD OF PROBING "HOT" ATOM PHENOMENA

Translation-to-vibration (T-V) excitation transfer processes are important in many related bulk kinetic properties of gases, including the collision dynamics in nozzle expansions, shock heated gases, transport phenomena, and luminescence from the upper atmosphere and interstellar media. Researchers at the Joint Institute for Laboratory Astrophysics (JILA) have developed a laser photolysis method for sensitive investigation of transient, translationally "hot" atom or radical energy transfer phenomena. The technique uses short pulses of ultraviolet light from an excimer laser to generate translationally fast atoms or radicals. The technique also uses wavelength and time-resolved infrared detection to monitor the molecular states excited in subsequent collision processes. The method is ideally suited to probe energy transfer phenomena in systems where reactive collision events play a competing role with excitation processes.

Stephen R. Leone, Quantum Physics Division, Joint Institute for Laboratory Astrophysics (JILA) and Department of Chemistry, University of Colorado, JILA A407A, 303/497-3505. Frank Magnotta, National Research Council postdoctoral fellow, Quantum Physics Division.

Broad absorption features exhibited by many molecules in the near ultraviolet offer the possibility of a continuous selection of fragment recoil energies over a large dynamic range with readily available lasers. With high-speed infrared and visible photodetectors or laser-induced fluorescence probes of molecular state excitation, a whole new class of modern translational excitation transfer experiments can be performed. Such investigations can be far more detailed than previous shock tube excitation and molecular beam energy loss experiments. The results will have significant impact on the study of transport phenomena, excitation processes in interstellar media, supersonic beam expansions, and combustion processes.

One such experiment has recently been performed in our laboratory* to investigate transient, translationally "hot" atom energy transfer phenomena involving the excitation of molecular vibrations. The fundamental features of the experiment are compellingly simple: (1) A short-pulsed excimer laser is used to photolyze weakly bound molecules well above the dissociation threshold, generating superthermal atoms or radical fragments with velocities precisely characterized by momentum and energy conservation. (2) These "hot" atoms undergo a well-specified succession of highly energetic collisions with a desired room temperature molecular "target" gas present in the sample. (3) Translation-to-vibration, rotation (T-V, R) energy transfer is observed by time-resolved infrared fluorescence detection of the vibrationally excited product species.

The key advantages of this laser-induced technique for detailed study of inelastic T-V energy transfer collision phenomena are several. First, the laser pulse affects only the velocity distribution of the photolyzed fragments. The "target" molecules remain fixed at room temperature. Second, the "hot" photofragments are highly reactive atoms or radicals. The technique is ideal for probing energy transfer phenomena in systems where reactive events may significantly alter the dynamics. Third, detection of the T-V excited product by infrared fluorescence is time resolved and state selective. Specific vibrational states as well as cascade processes that alter the initial distributions are readily observed. The net result is an extremely powerful technique for the detailed study of "hot" atom processes in the laboratory.

We performed the first experiments using translationally "hot" H atoms colliding with HCl and HBr. Excimer laser photolysis of HCl, HBr, or H_2S at 193 nm

This work was carried out in collaboration with David J. Nesbitt, Chemistry Department, University of Colorado.

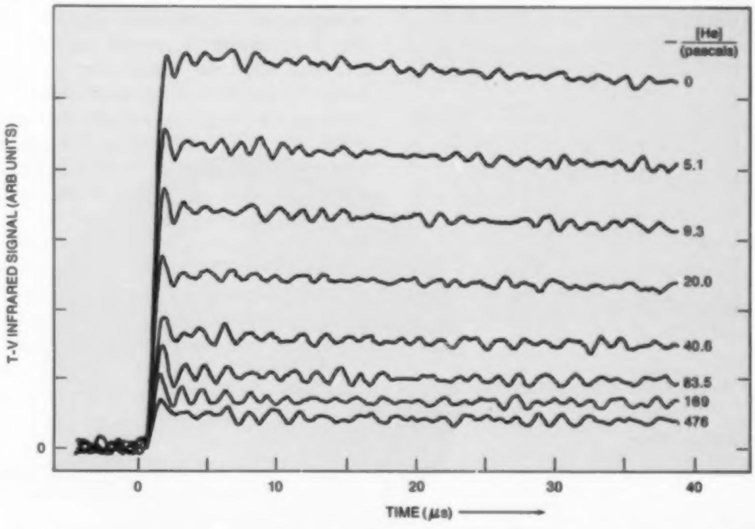


Figure 1—*Translation-to-vibration signal from HCl(v) excited by "hot" H atoms as a function of helium moderator gas pressure (133.332 pascals = 1 torr).*

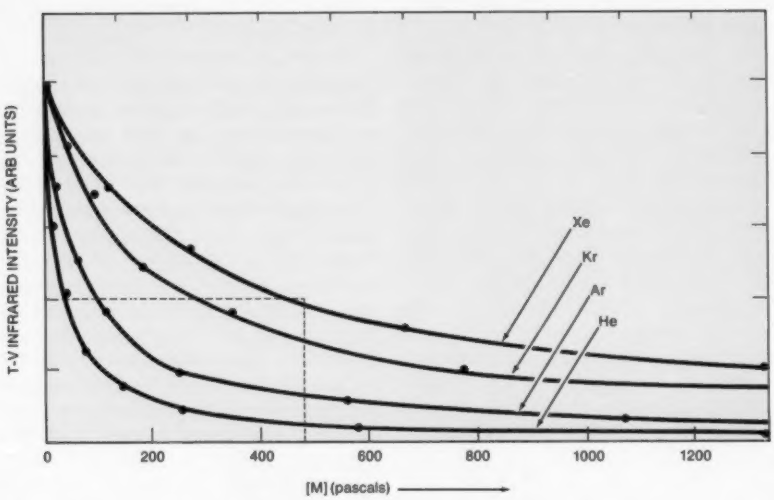


Figure 2—*HBr(v) translation-to-vibration energy transfer dependence on moderator pressure.*

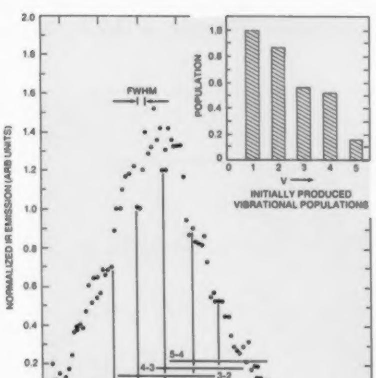


Figure 3—*Low resolution (50 cm⁻¹) spectrum of HCl(v) excited by translation-to-vibration transfer from "hot" H atoms. Vibrational bands and approximate state distribution are shown.*

produces H atoms with well-specified energies up to 250 kJ/mol. In contrast, a typical vibration requires only 30 kJ/mol. for excitation to v=1. Thus, the H atoms have sufficient energy to populate levels as high as v=8 in HCl and v=10 in HBr. The T-V transfer is readily apparent in HCl and HBr. An abrupt rise in vibrational fluorescence is observed upon collision of the "hot" atoms with the target molecules. A typical family of T-V transfer infrared signals from H + HCl is shown in Figure 1. The amplitude of the abrupt rise provides the measure of the T-V transfer efficiency. As the pressure of helium moderator gas is increased, the H atoms become thermal more rapidly, and a systematic reduction in infrared intensity is observed. The total observed T-V energy transfer results from a succession of progressively less energetic collisions; consequently the excitation represents an average over a sequence of decaying energies. We will perform experiments soon to obtain the results of single collision events.

Different mass buffer gases should exhibit distinctly different efficiencies for slowing the superthermal hydrogen atoms. Figure 2 shows the T-V signal intensity as a function of pressure for several moderator gases. The results are in excellent agreement with predictions of simple "billiard ball" momentum transfer slowing. Efficiencies of T-V transfer are extracted by calibration of the signal intensity and H-atom density and found to be on the order of 5–10 percent (energy efficiency).

Finally, the vibrational state distribution formed in the first few "hot" atom collisions was obtained from the low resolution spectrum shown in Figure 3. The approximate vibrational band positions and population distribution are shown. Excitation of vibrational levels as high as v=5 are observed to occur in single collision events. Simple models of T-V excitation predict vanishingly small probabilities for direct excitation of v=0 to v=5. Thus it is likely that reactive atom exchange collisions result in the excitation of the high levels observed.

With this new technique it will be possible to obtain some of the most accurate measurements of absolute cross sections for T-V transfer excitation, atom exchange probabilities, vibrational state distributions, and collisional slowing. The method will be used to obtain the velocity dependence of the cross sections and to provide detailed tests of fundamental T-V transfer theories. Electronically excited states, such as might be important in the aurora, can be produced by similar collision phenomena and may be studied by visible luminescence.

COAL SLURRY LEVEL MONITOR DEVELOPED

Investigators working on the problems of liquefaction of coal need a liquid level monitor (LLM) to track the level of a slurry of powdered coal in creosote or coal-derived fluid within a stainless steel high pressure vessel pressurized with hydrogen to 14 MPa. The LLM is required to provide a 0–10 volt dc analog output signal to operate high pressure control

valves. Since adequate instrumentation is not commercially available, the Department of Energy (DOE) requested that the National Bureau of Standards help on the problem. Researchers at NBS designed and built an LLM to meet that need. This instrument is a direct spin-off from and closely related to a high pressure viscometer developed earlier at NBS.

Vern E. Bean and Frederick G. Long, Jr., Temperature and Pressure Measurements and Standards Division, A149 Metrology Building, 301/921-2121.

The unique feature of the LLM is the level sensor, a float which will tolerate the pressure and yet support enough magnetic material to be traced by an arrangement of coils external to the pressure vessel.

Among the advantages this sensor offers over other proposed methods are: a) it requires no penetration through the pressure vessel wall, b) it requires no voltages in the high pressure hydrogen environment, and c) its operation is independent of the electrical properties of the slurry which are not constant due to the varying water content of the coal.

Floats, in the shape of a toroid for stability, have been made of polypropylene, low density polyethylene, and epoxy filled with glass microballoons which have relative densities of 0.90, 0.92, and 0.70 respectively. All these materials have been pressure tested to 30 MPa in creosote without failure.

The magnetic material is mumetal. Three bands weighing about 1 gram each are anchored symmetrically around the toroid.

The tracking system employs two sets of coils, each consisting of a primary and a secondary coil wound side-by-side on the same winding form. The four coils are virtually identical. The winding forms slip over the outside of the pressure vessel and are anchored in place with set screws. The schematic/block diagram is shown in Figure 1. The relative positions of the coils are adjusted so that the signal in the bottom secondary coil is at its maximum with the float in the lowest position. As the float rises, the signal in the bottom secondary coil decreases due to the decrease in the primary-secondary coupling through the mumetal. The signal reaches a steady state as the float moves out of the area of influence of the bottom secondary coil. After demodulation by the detector, the signal is a dc voltage, decreasing to a constant value. As the float continues to rise, the increasing coupling through the mumetal results in a signal in the top secondary coil that is the mirror image of the signal in the bottom secondary coil. The divider provides a signal

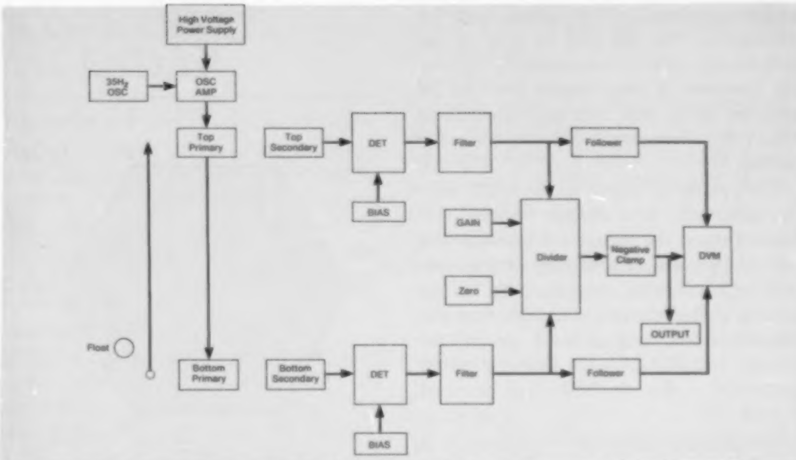
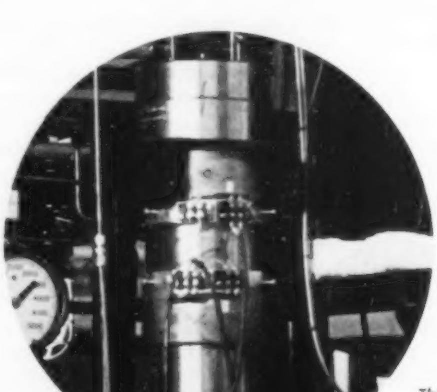


Figure 1—*As the float rises, the magnetic coupling between the bottom primary and secondary coils decreases resulting in a decreasing signal in the lower branch of the circuit. The coupling between the top coil pair increases providing an increasing signal in the top branch. The ratio of these two signals from the divider can be adjusted by the zero and gain controls to provide a 0-10 volt dc signal for operating high pressure control valves.*



The liquid level monitor tracking coils are shown mounted on a 2-liter, high-pressure vessel in the coal liquefaction laboratory at the Pittsburgh Energy Technology Center.

which is the ratio of the voltage from the detector of the top coil to that of the bottom coil. It is a monotonically increasing function of float height and can be adjusted using zero and gain controls to obtain the necessary 0–10 volts for valve control.

The system is stable to ± 0.025 volt. The sensitivity to a change of level will depend upon the separation between the sets of coils and the setting of the zero and gain controls. For example, if we assume the conditions are such that the observable height span is 15 cm for the voltage span of 0–10 volts, then the height sensitivity at the ± 0.025 volt level is ± 0.04 cm.

The LLM has been installed in a coal liquefaction laboratory at DOE's Pittsburgh Energy Technology Center. At DOE's request, a patent application has been submitted.

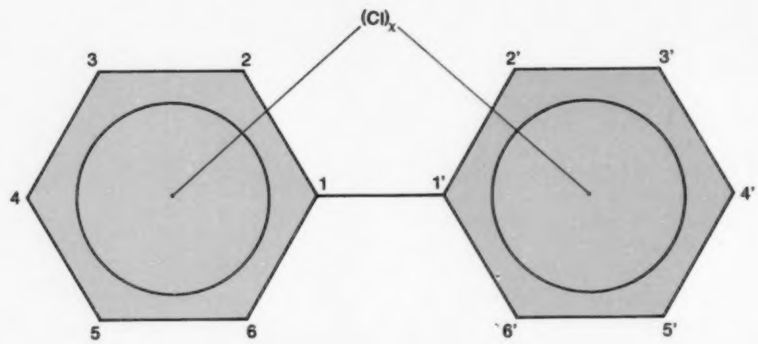


Figure 1—*Structure of the polychlorinated biphenyl molecule. Chlorination is possible at any numbered site (except 1 and 1') yielding a total of 209 combinations.*

MEASURING PCB'S IN LUBRICATING AND COOLING OILS

Scientists at the NBS Center for Analytical Chemistry have successfully developed a method for determining polychlorinated biphenyls (PCB's) in a hydrocarbon matrix. It is now possible to monitor the toxic PCB's in transformer coolants and motor oils. This procedure is being used to certify a Standard Reference Material entitled "Polychlorinated Biphenyls in Oil."

Stephen N. Chesler, Reenie M. Parris, and Willie E. May, Organic Analytical Research Division, A113 Chemistry Building, 301/921-2153.

Polychlorinated biphenyl mixtures have been used extensively in this country as coolants in high-voltage electrical components. These toxic compounds may be introduced into the environment when the electrical components in which they are contained are serviced, repaired, or discarded. The PCB fluid physically resembles lubricating oil, and there have been instances in which toxic PCB's have been mistakenly added to motor oils being collected for recycling purposes.

PCB's are neutral organic compounds (see Figure 1) possessing no chemical characteristics that will allow them to be easily segregated from a hydrocarbon matrix such as a lubricating oil or transformer cooling oil. Determining PCB's in these oils by normal gas chromatographic methods is not feasible without chemical "clean-up" to remove analytical interferences.

We have tried a number of procedures, such as solvent extraction, sulfuric acid partitioning, and normal-column chromatography, to clean up the sample prior to analysis and found them to be time-consuming and inadequate. Accordingly, we developed a new hybrid chromatographic technique which makes use of both gas chromatography and high-performance liquid chromatography (HPLC).

We first use HPLC to remove the major interfering components in the oil sample. The "clean" sample is then separated into its component parts on a nonpolar, wall-coated, open-tublar (WCOT) gas chromatographic column. Using both an electron capture detector (ECD) and a Hall electrolytic conductivity detector (HECD), we have analyzed a number of used motor oil samples containing a wide range of concentrations and types of PCB contamination. The HECD has been found to be more applicable for this analysis due to its linear response characteristics. This method is sensitive to less than 1 ppm PCB. The majority of the PCB's are resolved, and peak-by-peak comparison of the oil fraction chromatogram with chromatograms of commercial PCB mixtures can be made.

We are currently working to prepare and certify (using the developed methodology) a PCB Standard Reference Material (SRM) consisting of separate solutions of two commercial PCB mixtures in a transformer oil and a motor oil base. This SRM will be useful to the electrical industry where PCB contamination of transformer cooling fluid is of current concern, and in the motor oil recycling (re-refining) industry where inadvertent contamination of the recycling stock by PCB-containing fluids is a problem. In addition to the certification of total PCB content, we plan to measure selected single PCB isomers.

CONFERENCES

For general information on NBS conferences, contact Greta Pignone, NBS Public Information Division, Washington, DC 20234, 301/921-2721.

INFORMATION TECHNOLOGY DEVELOPMENTS CONFERENCE

Papers are now being solicited for the "Trends and Applications 1982: Advances in Information Technology" conference to be held at the National Bureau of Standards in Gaithersburg, Md., on May 27, 1982.

The event is cosponsored by the NBS Institute for Computer Sciences and Technology, the Washington, D.C., Chapter of the Institute of Electrical and Electronics Engineers (IEEE) Computer Society, and the IEEE Washington Section.

The theme of the conference is information technology developments impacting the 80's. Of particular interest to the program committee will be papers covering developments in:

—advanced computer architecture,
—advanced graphics technology,
—distributed processing,
—office automation technology,
—networking technology,
—software technology, and
—database management technology.

Also welcome are papers which deal with evolving applications for advanced information technology and the social consequences of such innovations.

Authors of papers should submit three copies of a 1000-word abstract by December 15, 1981, to Allen Hankinson, A209 Administration Building, National Bureau of Standards, Washington, DC 20234. Authors will be notified of provisional acceptance by January 30, 1982. Camera-ready copy for published proceedings must be available by March 20, 1982.

Hankinson is program chairperson. Other conference committee members are Leon Scharff, ADPESO, Department of Navy, Washington, DC 20376 301/433-2547, and Elizabeth Parker, NBS Liaison, National Bureau of Standards, A209 Administration Building, Washington, DC 20234 301/921-2834.

CONFERENCE CALENDAR

*November 4-6

ARSENIC SYMPOSIUM—PRODUCTION AND USE—BIOMEDICAL AND ENVIRONMENTAL PERSPECTIVES, NBS, Gaithersburg, MD; sponsored by NBS and the Chemical Manufacturers Association; contact: Lottie McClendon, A261 Metrology Building, NBS, 301/921-3775.

November 23-24

DEFORMATION, FRACTURE, WEAR, AND NONDESTRUCTIVE EVALUATION OF MATERIALS: PHYSICS AND PRACTICE, New Orleans, LA; sponsored by NBS and APS; contact: Robb Thomson, A311 Materials Building, NBS, 301/921-2103.

*December 8

COMPUTER NETWORKING SYMPOSIUM, NBS, Gaithersburg, MD; sponsored by NBS and IEEE; contact: Robert Toense, B226 Technology Building, NBS, 301/921-3516.

1982

*January 19-21

SYMPOSIUM ON SILICON PROCESSING, San Jose, CA; sponsored by NBS and ASTM; contact: Elaine Cohen, A308 Technology Building, NBS, 301/921-3427.

*March 3

FIPS SOFTWARE DOCUMENTATION WORKSHOP, NBS, Gaithersburg, MD; sponsored by NBS; contact: Albrecht Neumann, A265 Technology Building, NBS, 301/921-3485.

*March 14-18

SIXTH SYMPOSIUM ON TEMPERATURE—ITS MEASUREMENT AND CONTROL IN SCIENCE AND INDUSTRY, Washington Hilton Hotel, Washington, DC; sponsored by NBS, Instrument Society of America, and American Institute of Physics; contact: James Schooley, B130 Physics Building, NBS, 301/921-3315.

*March 15-17

HUMAN FACTORS IN COMPUTER SYSTEMS, NBS, Gaithersburg, MD; sponsored by NBS and ACM; contact: Wilma Osborne, A265 Technology Building, NBS, 301/921-3485.

*March 22-26

FOURTH ASTM-EURATOM SYMPOSIUM, NBS, Gaithersburg, MD; sponsored by NBS and ASTM; contact: Charles Eisenhauer, C310 Radiation Physics Building, NBS, 301/921-2658.

*March 29-April 2

AMERICAN CRYSTALLOGRAPHERS ASSOCIATION, NBS, Gaithersburg, MD; sponsored by NBS and Crystallographers Association; contact: Camden Hubbard, A221 Materials Building, NBS, 301/921-2921.

*April 20-22

MECHANICAL FAILURES PREVENTION GROUP, NBS, Gaithersburg, MD; sponsored by NBS and MFPG; contact: T. Robert Shives, B120 Materials Building, NBS, 301/921-2934.

*June 1-4

NEUTRON TRANSMUTATION DOPING CONFERENCE, NBS, Gaithersburg, MD; sponsored by NBS; contact: Robert Larrabee, A360 Technology Building, NBS, 301/921-3625.

*June 7-9

SEVENTH INTERNATIONAL SYMPOSIUM ON ULTRASONIC IMAGING AND TISSUE CHARACTERIZATION, NBS, Gaithersburg, MD; sponsored by NBS, NIH, IEEE, and AIUM; contact: Melvin Linzer, A366 Materials Building, NBS, 301/921-2611.

*October 4-8

NATIONAL CONFERENCE OF STANDARDS LABORATORIES, NBS, Gaithersburg, MD; sponsored by NBS and NCSL; contact: Brian Belanger, B362 Physics Building, NBS, 301/921-2805.

*October 26-28

FOURTH IFAC/IFIP SYMPOSIUM, NBS, Gaithersburg, MD; sponsored by NBS, the International Federation of Automatic Control, and the International Federation for Information Processing; contact: James Albus, A123 Metrology Building, NBS, 301/921-2381.

** New Listings*

PUBLICATIONS

HYDROGEN DATA FOR ENERGY SYSTEMS PUBLISHED

*McCarthy, R. D., Hord, J., and Roder, H. M., Selected Properties of Hydrogen, Nat. Bur. Stand. (U.S.), Monogr. 168, 523 pages (Feb. 1981) Stock No. 003-003-02296-9, $16 prepaid.**

Scientists and engineers engaged in the research and design of energy systems will find help in a new National Bureau of Standards reference publication dealing with the physical properties of hydrogen. Titled *Selected Properties of Hydrogen* (NBS Monograph 168), the book compiles 20 years of NBS research.

In compiling the data, the authors considered varied energy-related fields, including magnetohydrodynamics; electrolysis and thermochemical decomposition of water, coal and shale derivative fuels, solar and wind power, ocean energy, and geothermal processes. Thus, the publication encompasses comprehensive coverage of hydrogen over a wide range of pressures and temperatures to satisfy the data demands of the broadening spectrum of interests.

Ortho-para modification of the hydrogen molecule is taken into consideration in presenting the properties of data. Normal hydrogen (75 percent ortho and 25 percent para content) data are given for high temperature processes such as thermochemical decomposition, electrolysis, coal gasification, and other synthetic fuel production processes. Parahydrogen (0.21 percent ortho and 99.79 percent para content) data are provided for low temperature processes such as cryogenic purification, subliming refrigerators, and liquid transport and storage.

Hydrogen, methane, and gasoline combustion characteristics are included. These data offer a basis for safety assessments of hydrogen fuels in various applications.

Engineering process design data are also included, such as pressurization and heat transfer parameters, mixture properties, slush hydrogen technology, ortho-para modification, and isotope properties.

The 523-page book consists of 62 figures, 30 tables, 519 references, and supporting text. New figures and tables adhere to the SI (metric) system of units. Dual units or SI unit conversion factors are provided throughout the text where original non-SI data are reported or discussed.

Chapters include:

Chapter 1: Thermophysical properties of liquid, liquid-vapor, and gaseous hydrogen;

Chapter 2: Thermophysical properties of solid-liquid, solid-vapor, and solid hydrogen;

Chapter 3: Chemical and physical data for combustion characteristics of hydrogen;

Chapter 4: Miscellaneous properties of hydrogen;

Chapters 5 and 6: Figures, charts, and tables which pertain to the properties data presented in chapters one through four; and

Chapter 7: Physical constants, symbols, and defined mix of engineering and scientific units used in the text.

Representing an extensive compilation of hydrogen properties data, the publication will assist those in industry, government, and academia as a reference book.

*Publications cited here may be purchased at the listed price from the U.S. Government Printing Office, Washington, DC 20402 (foreign: add 25 percent). Microfiche copies are available from the National Technical Information Service, Springfield, VA 22161. For more complete periodic listings of all scientific papers and articles produced by NBS staff, write: Editor, Publications Newsletter, Administration Building, National Bureau of Standards, Washington, DC 20234.

A STEP BY STEP GUIDE

Rawie, C. C., Estimating Benefits and Costs of Building Regulations, Nat. Bur. Stand. (U.S.), NBSIR 81-2223, 67 pages (June 1981). Order by Stock No. PB 81-217812 from National Technical Information Services, Springfield, VA 22161; $9.50 prepaid.

The use of economic analysis tools to aid communities in making decisions about building code changes is detailed in a "how-to" guide just issued by the National Bureau of Standards.

In *Estimating Benefits and Costs of Building Regulations: A Step by Step Guide* (NBSIR 81-2223), economist Carol Chapman Rawie of the NBS Center for Building Technology describes analytical methods that "can help those who are involved in code changes to make reasonable tradeoffs among competing demands for increased building safety, increased building performance, and reduced building costs." The handbook is designed for building officials, elected officials, builders, architects, engineers, trade association members, and others involved in code change decisions who need to determine the cost effectiveness of such changes.

Benefit-cost analysis techniques are outlined in the report as a series of steps beginning with definition of the problem and selection of prototype buildings. Some steps involve estimating the impact of code changes on building-related costs, on building safety and performance, and on the building code jurisdiction as a whole. Another step calls for performing a sensitivity analysis, defined as a method for finding out how changes in data or assumptions will affect the final results.

Procedures are given for computing net monetary benefits of a proposed code provision, and a technique is described for "aggregating" the effect on many buildings in the code jurisdiction.

Worksheets are provided. Also included are tables of discount factors (used for finding a common basis for costs and benefits occurring at different times), a glossary of economic terms, and a recommended reading list.

PUBLISHED PROCEEDINGS OF IMPLANT CONFERENCE

Weinstein, A., Gibbons, D., Brown, S., and Ruff, W., Eds., Implant Retrieval: Material and Biological Analysis, Nat. Bur. Stand. (U.S.), Spec. Publ. 601, 772 pages (Jan. 1981) Stock No. 003-003-02292-6, for $12 prepaid.

The performance of orthopedic and cardiovascular implants is the subject of a new publication released by the National Bureau of Standards. *Implant Retrieval: Materials and Biological Analysis* includes 26 invited papers presented at a conference by the same name held at NBS on May 1 and 2, 1980. The conference was sponsored by the Bureau along with several other Government agencies.

Also included are the proceedings of a workshop on implant retrieval data systems and recommendations for standardization of these systems to improve the usability of research data gathered during different types of implant investigations.

The 776-page book contains the complete texts of technical papers presented at the conference under the broad categories of bulk phenomena, release phenomena, interface phenomena, and information utilization. Individual papers are extensively illustrated with photographs of different types of implant materials before use and after removal from patients and with diagrams of laboratory implant testing devices. In addition, these papers include data on implant failure modes and biocompatibility problems.

PUBLICATIONS LISTING

Acoustics and Sound

Younglove, B. A., Velocity of Sound in Liquid Propane, J. Res. Nat. Bur. Stand. (U.S.), 86, No. 2, 165-170 (Mar.-Apr. 1981).

Atomic and Molecular Studies

Gallagher, J. W., Van Blerkom, J., Beaty, E. C., and Rumble, J. R., Jr., Data Index for Energy Transfer Collisions of Atoms and Molecules 1970-1979, Nat. Bur. Stand. (U.S.), Spec. Publ. 593, 346 pages (Apr. 1981) Stock No. 003-003-02315-9, $8 prepaid.

Building Technology

Mahajan, B. M., Galowin, L. S., and Kopetka, P. A., Models of Quasi-Steady and Unsteady Discharge from Plumbing Fixtures, J. Res. Nat. Bur. Stand. (U.S.), 86, No. 2, 171-179 (Mar.-Apr. 1981).

Computer Science and Technology

Berg, J. L., Graham, M., and Whitney, K., Eds., Computer Science and Technology: Database Architectures—A Feasibility Workshop Report, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-76, 64 pages (Apr. 1981) Stock No. 003-003-02305-1, $4 prepaid.

Branstad, M. A., and Adrion, W. R., Eds., Computer Science and Technology: NBS Programming Environment Workshop Report, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-78, 106 pages (June 1981) Stock No. 003-003-02334-5, $4.75 prepaid.

Cugini, J. V., Computer Science and Technology: Specifications and Test Methods for Numeric Accuracy in Programming Language Standards, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-77, 42 pages (June 1981) Stock No. 003-003-02324-8, $2.75 prepaid.

Consumer Information and Protection

Brickenkamp, C. S., Hasko, S., and Natrella, M. G., Checking the Net Contents of Packaged Goods, Nat. Bur. Stand. (U.S.), Handb. 133, 164 pages (June 1981) Stock No. 003-003-02331-1, $6 prepaid.

Electronic Technology

Carver, G. P., and Cullins, W. A., Semiconductor Measurement Technology: A Manual Wafer Probe Station for an Integrated Circuit Test System, Nat. Bur. Stand. (U.S.), Spec. Publ. 400-68, 19 pages (May 1981) Stock No. 003-003-02319-1, $2 prepaid.

Schafft, H. A., Ruthberg, S., and Cohen, E. C., Eds., Semiconductor Measurement Technology: ARPA/NBS Workshop V, Moisture Measurement Technology for Hermetic Semiconductor Devices. Proceedings of the ARPA/NBS Workshop V held at the National Bureau of Standards March 22-23, 1978, Gaithersburg, MD, Nat. Bur. Stand. (U.S.), Spec. Publ. 400-69, 202 pages (May 1981) Stock No. 003-003-02326-4, $6 prepaid.

Thurber, W. R., Mattis, R. L., Liu, Y. M., and Filliben, J. J., Semiconductor Measurement Technology: The Relationship Between Resistivity and Dopant Density for Phosphorus- and Boron-Doped Silicon, Nat. Bur. Stand. (U.S.), Spec. Publ. 400-64, 53 pages (May 1981) Stock No. 003-003-02320-5, $3.25 prepaid.

Energy Conservation and Production

Berry, S. A., Ed., Research and Innovation in the Building Regulatory Process. Proceedings of the Fifth Annual NBS/NCSBCS Joint Conference Technical Seminar on Solar Energy and Energy Conservation, August 6, 1980, Denver, CO, Nat. Bur. Stand. (U.S.), Spec. Publ. 608, 20 pages (May 1981) Stock No. 003-003-02321-3, $6 prepaid.

Engineering, Product, and Information Standards

Debelius, J. R., Standards Committee Activities of the National Bureau of Standards, 1980 Highlights, Nat. Bur. Stand. (U.S.), Spec. Publ. 605, 102 pages (May 1981) Stock No. 003-003-02327-2, $4.50 prepaid.

Health and Safety

Clark, H. E., Requirements for an Effective National Nonionizing Radiation Measurement System, Nat. Bur. Stand. (U.S.), Spec. Publ. 613, 41 pages (June 1981) Stock No. 003-003-02335-5, $2.75 prepaid.

Rubin, A. I., and Howett, G. L., Emergency Vehicle Warning Systems, Nat. Bur. Stand. (U.S.), Spec. Publ. 480-37, 25 pages (May 1981) Stock No. 003-003-02323-0, $2.75 prepaid.

Low Temperature Science and Engineering

Zimmerman, J. E., Sullivan, D. B., and McCarthy, S. E., Eds., Refrigeration for Cryogenic Sensors and Electronic Systems. Proceedings of a Conference held at the National Bureau of Standards, October 6-7, 1980, Boulder, CO, Nat. Bur. Stand. (U.S.), Spec. Publ. 607, 223 pages (May 1981) Stock No. 003-003-02310-8, $6.50 prepaid.

Mathematical and Statistical Methods

Pearl, M. H., and Goldman, A. J., A Game-Theoretic Model of Inspection-Resource Allocation, J. Res. Nat. Bur. Stand. (U.S.), 86, No. 2, 193-215 (Mar.-Apr. 1981).

Shier, D. R., and Witzgall, C., Properties of Labeling Methods for Determining Shortest Path Trees, J. Res. Nat. Bur. Stand. (U.S.), 86, No. 3 317-330, (May-June 1981).

Measurement Science and Technology: Policy and State-of-the-Art Surveys

Driver, R. G., Houck, J. C., and Welch, B. E., An Intercomparison of Pressure Standards Between LNE and NBS, J. Res. Nat. Bur. Stand. (U.S.), 86, No. 3, 277-279 (May-June 1981).

Metrology: Physical Measurements

Magin, R. L., Mangum, B. W., Statler, J. A., and Thornton, D. D., Transition Temperatures of the Hydrates of Na_2SO_4, Na_2HPO_4, and KF as Fixed Points in Biomedical Thermometry, J. Res. Nat. Bur. Stand. (U.S.), 86, No. 2, 181-192 (Mar.-Apr. 1981).

Processing and Performance of Materials

Graminski, E. L., and Parks, E. J., The Effect of Calcium Carbonate on the Stability of Acid Treated Papers, J. Res. Nat. Bur. Stand. (U.S.), 86, No. 3, 309-315 (May-June 1981).

Properties of Materials: Thermodynamic and Transport

deCastro, C. A. N., and Roder, H. M., Absolute Determination of the Thermal Conductivity of Argon at Room Temperature and Pressures Up to 68 MPa, J. Res. Nat. Bur. Stand. (U.S.), 86, No. 3, 293-307 (May-June 1981).

NEWS BRIEFS

MICROWAVE POWER MAP. The NBS Electromagnetic Technology Division is currently organizing a measurement assurance program (MAP) in microwave power among major west coast aerospace industries and microwave instrument manufacturers. The program is being built upon experience with the NBS/Department of Defense microwave-power MAP, now in its third year. All laboratories participating in this program will measure one set of standards calibrated by NBS. This provides calibration traceability to NBS with the added advantage of revealing any systematic errors in the participants' equipment and/or procedures. Similar MAP's are planned for central U.S. and east coast industries.

RADIO FREQUENCY TESTING STANDARD BEING DEVELOPED. NBS scientists are developing a standard radiating device that Government and industry can use to calibrate the accuracy of various radio frequency test facilities. The small, spherical dipole radiator is self-contained and, hopefully, will be used as a transfer standard. It has been tested successfully at 30 MHz and resonant frequencies up to 240 MHz. NBS hopes eventually to provide a frequency range from 10 MHz up to 1 GHz. A paper describing the radiator is available.

ION-MOLECULE REACTIONS STUDIED. Researchers at the Joint Institute for Laboratory Astrophysics have developed a new technique for measuring ion-molecule reaction rates, and have used the method to determine the rate at which nitrogen and carbon ions react with hydrogen gas at a temperature of 10 kelvins (minus 263 °C). Previously, ion reactions were measurable only to 80 kelvins. Their work will enable scientists to study some physical-chemical reactions never before measurable. It will also help astrophysicists draw more accurate models of the way atoms and molecules are formed in interstellar space.

SOLID FUELS PROPERTIES PROGRAM. A solid fuels properties research program has been initiated by NBS' Center for Chemical Engineering. In response to the need for expanded thermophysical properties data for solid fuels, NBS is validating the precision and accuracy of new measurement equipment, assessing conventional measurement procedures, and interpreting the results. Ultimately, the program will emphasize the development of accurate, data-predictive techniques applicable to solid fuels, such as coal and oil shale, and complex heterogeneous solids like natural gas hydrates. To a large extent, the work will be collaborative with industry, professional organizations, academia, and other laboratories.

TRACE METALS IN THE CHESAPEAKE BAY. Using a novel combination of sampling and detection techniques, NBS researchers have measured appreciable amounts of toxic organotin compounds in polluted areas of the Chesapeake Bay. During this study, NBS researchers developed an analytical technique for simultaneously detecting and identifying both volatile and non-volatile organotin compounds in solution. The new system includes a commercially available purge and trap sampler, a gas chromatograph, and flame photometric detector which are linked in sequence to allow ultratrace speciation.

NEXT MONTH IN

DIMENSIONS/NBS

Do you ever "listen" to the stars? Radio astronomers do and have made some discoveries which shed new light on the evolution of stars like our sun. Read about these findings in the next issue of DIMENSIONS/NBS.

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The Commerce Department's National Bureau of Standards was established by Congress in 1901 to advance the Nation's science and technology and to promote their application for public benefit. NBS research projects and technical services are carried out by the National Measurement Laboratory, the National Engineering Laboratory, and the Institute for Computer Sciences and Technology. Manufacturing, commerce, science, government and education are principal beneficiaries of NBS work in the fields of scientific research, test method developments, and standards writing. DIMENSIONS/NBS describes the work of NBS and related issues and activities in areas of national concern such as energy conservation, fire safety, computer applications, materials utilization, and consumer product safety and performance. The views expressed by authors do not necessarily reflect policy of the National Bureau of Standards or the Department of Commerce.

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Annual subscription: Domestic, $11.00, foreign, $13.75. Single copy: $2.25, foreign, $2.85. The Secretary of Commerce has determined that the publication of the periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through June 30, 1982.

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